WHAT IS CLAIMED IS:

1. A method for vascular elastography comprising:

providing pre-tissue-motion and post-tissue-motion images in digital form of a vessel delimited by a vascular wall; said pre-tissue-motion and post-tissue-motion images being representative of first and second time-delayed configuration of said vessel;

partitioning at least portions of both said pre-tissue-motion and post-tissue-motion images into corresponding data windows;

approximating a trajectory between said pre-tissue-motion and post-tissue-motion images for corresponding data windows; and

using the trajectory for each data window to compute a strain tensor in each data window.

2. A method as recited in claim 1, further comprising using said strain tensor in each data window to create an elastogram of at least part of said vessel.

3. A method as recited in claim 1, wherein said pre-tissue-motion and post-tissue-motion images are radio-frequency (RF) images.

4. A method as recited in claim 3, wherein said pre-tissue-motion and post-tissue-motion images are part of a sequence of radio-frequency (RF) images.

5. A method as recited in claim 1, wherein said pre-tissue-motion and post-tissue-motion images are issued from magnetic

resonance imaging (MRI), optical coherence tomography (OCT), brightness mode (B-mode) or Doppler-based ultrasound modality imaging.

6. A method as recited in claim 1, wherein providing pre-tissue-motion and post-tissue-motion images in digital form of a vessel includes inducing tissue compression or dilatation on said vessel.

7. A method as recited in claim 6, wherein inducing tissue dilatation on said vessel is achieved by cardiac pulsation.

8. A method as recited in claim 1, wherein said strain tensor is the full strain tensor in at least one of said data windows.

9. A method as recited in claim 8, wherein said full strain tensor is computed from three-dimensional or two-dimensional ultrasound data.

10. A method as recited in claim 8, further comprising using said full strain tensor to compute the Von Mises (VM) coefficient in each data window.

11. A method as recited in claim 1, wherein approximating a trajectory for each said data window includes using a Lagrangian speckle model estimator (LSME).

12. A method as recited in claim 1, wherein a trajectory is approximated in each said data window using zero-order and first-order terms of a Taylor-series expansion, yielding:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \underbrace{\begin{bmatrix} x(0,0,0,t) \\ y(0,0,0,t) \\ z(0,0,0,t) \end{bmatrix}}_{Tr} + \underbrace{\begin{bmatrix} \frac{\partial x}{\partial x_0} & \frac{\partial x}{\partial y_0} & \frac{\partial x}{\partial z_0} \\ \frac{\partial y}{\partial x_0} & \frac{\partial y}{\partial y_0} & \frac{\partial y}{\partial z_0} \\ \frac{\partial z}{\partial x_0} & \frac{\partial z}{\partial y_0} & \frac{\partial z}{\partial z_0} \end{bmatrix}_{(0,0,0,t)}}_{LT} \begin{bmatrix} x_0 \\ y_0 \\ z_0 \end{bmatrix}$$

where [Tr] is a translation vector

[LT] is a linear geometrical transformation of coordinates

(x, y, z) represents the new position of a point (x_0, y_0, z_0).

13. A method as recited in claim 12, wherein using said trajectory for each said data window to compute a strain tensor in each data window includes performing a non-linear minimization for each data window W_{ij} by computing a transformation [LT] providing the best match between each W_{ij} of said pre-tissue motion image and a corresponding window W_{ij} in said post-tissue motion image.

14. A method as recited in claim 12, further comprising computing the full strain tensor ε having the components ε_{ij} wherein:

$$\varepsilon_{ij}(t) = \frac{1}{2}\left[\Delta_{ij}(t) + \Delta_{ji}(t)\right]$$

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \begin{bmatrix} x - x_0 \\ y - y_0 \\ z - z_0 \end{bmatrix} = \underbrace{\begin{bmatrix} x(0,0,0,t) \\ y(0,0,0,t) \\ z(0,0,0,t) \end{bmatrix}}_{Tr} + \Delta \begin{bmatrix} x_0 \\ y_0 \\ z_0 \end{bmatrix}, \text{ with:}$$

$$\Delta = \underbrace{\begin{bmatrix} \frac{\partial x}{\partial x_0} - 1 & \frac{\partial x}{\partial y_0} & \frac{\partial x}{\partial z_0} \\ \frac{\partial y}{\partial x_0} & \frac{\partial y}{\partial y_0} - 1 & \frac{\partial y}{\partial z_0} \\ \frac{\partial z}{\partial x_0} & \frac{\partial z}{\partial y_0} & \frac{\partial z}{\partial z_0} - 1 \end{bmatrix}_{(0,0,0,t)}}_{LT-I}$$

(u, v, w) being displacement vector in the Cartesian coordinate system.

15. A method as recited in claim 14, further comprising determining an elastogram providing a distribution of each component of the deformation matrix Δ and of the strain tensor ε.

16. A method as recited in claim 15, further comprising computing a pressure gradient between said pre-tissue-motion and post-tissue-motion images; said pressure gradient being used in determining said elastogram.

17. A method as recited in claim 15, further comprising computing the Von Mises (VM) ξ coefficient in at least some of said data windows as:

$$\xi = \left\{ \frac{2}{9} \left[(\varepsilon_{xx} - \varepsilon_{yy})^2 + (\varepsilon_{yy} - \varepsilon_{zz})^2 + (\varepsilon_{zz} - \varepsilon_{xx})^2 + 6(\varepsilon_{xy}^2 + \varepsilon_{yz}^2 + \varepsilon_{xz}^2) \right] \right\}^{1/2}$$

18. A method as recited in claim 17, further comprising determining a composite elastogram providing a distribution of the VM coefficient in at least some of said data windows.

19. A method as recited in claim 17, further comprising:

providing pressure gradient σ resulting from blood flow pulsation of said vessel when said pre-tissue motion and post-tissue motion images are taken; and

computing the elastic modulus in at least some of said data windows as:

$$E = \frac{\sigma}{\xi}$$

20. A method as recited in claim 12, wherein using said trajectory for each said data window to compute a strain tensor in each data window includes solving the following minimization equation:

$$\underset{\Psi_{ij}}{MIN} \left\| I(x(t_0), y(t_0), z(t_0)) - I_{Lag}(x(t_0 + \Delta t), y(t_0 + \Delta t), z(t_0 + \Delta t)) \right\|^2$$

where ψ_{ij} = [Tr;LT(:)] for data window W_{ij} for augmented vector (;) and matrix vectorisation (:)

$I_{Lag}(x(t_0 + \Delta t), y(t_0 + \Delta t), z(t_0 + \Delta t))$ is the Lagrangian speckle image (LSI) defined as the post-tissue motion image $I(x(t_0 + \Delta t), y(t_0 + \Delta t), z(t_0 + \Delta t))$ numerically compensated for tissue motion.

21. A method as recited in claim 20, wherein solving said minimization equation includes using a minimization algorithm.

22. A method as recited in claim 21, wherein said minimization algorithm is the regularized nonlinear minimization Levenberg-Marquardt (L&M) minimization algorithm.

23. A method as recited in claim 12, wherein using said trajectory for each said data window to compute a strain tensor in each data window includes solving in a region of interest represented in both said pre-tissue-motion and post-tissue-motion images characterized by p x q pixels:

$$\begin{bmatrix} I_{x_1}x_1 & I_{x_1}y_1 & I_{x_1}z_1 & I_{x_1} & \cdots & I_{z_1}x_1 & I_{z_1}y_1 & I_{z_1}z_1 & I_{z_1} \\ I_{x_2}x_2 & I_{x_2}y_2 & I_{x_2}z_2 & I_{x_2} & \cdots & I_{z_2}x_2 & I_{z_2}y_2 & I_{z_2}z_2 & I_{z_2} \\ \vdots & \vdots & \vdots & \vdots & & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \cdots & \vdots & \vdots & \vdots & \vdots \\ I_{x_{p\times q}}x_{p\times q} & I_{x_{p\times q}}y_{p\times q} & I_{x_{p\times q}}z_{p\times q} & I_{x_{p\times q}} & \cdots & I_{z_{p\times q}}x_{p\times q} & I_{z_{p\times q}}y_{p\times q} & I_{z_{p\times q}}z_{p\times q} & I_{z_{p\times q}} \end{bmatrix} \begin{bmatrix} \Delta_{xx} \\ \Delta_{xy} \\ \Delta_{xz} \\ t_x \\ \Delta_{yx} \\ \Delta_{yy} \\ \Delta_{yz} \\ t_y \\ \Delta_{zx} \\ \Delta_{zy} \\ \Delta_{zz} \\ t_z \end{bmatrix} = \begin{bmatrix} \tilde{I}_{t_1} \\ \tilde{I}_{t_2} \\ \vdots \\ \vdots \\ \tilde{I}_{t_{p\times q}} \end{bmatrix}$$

for each corresponding said pixels in said pre-tissue motion and post-tissue motion images in digital form;

where $t_x = x(0,0,0,t)$; $t_y = y(0,0,0,t)$; $t_z = z(0,0,0,t)$; and $\tilde{I}_t = \left(I_{Lag}\left(x(t+dt), y(t+dt), z(t+dt)\right) - I\left(x(t), y(t), z(t)\right)\right)$.

24. A method as recited in claim 1, wherein providing pre-tissue motion and post-tissue motion images in digital form includes collecting longitudinal and cross-sectional radio-frequency (RF) data from said vessel.

25. A method recited in claim 1 for endovascular elastography (EVE).

26. A method as recited in claim 24, wherein providing pre-tissue-motion and post-tissue-motion images includes acquiring intravascular RF images using a catheter.

27. A method as recited in claim 26, wherein acquiring intravascular RF images using a catheter includes sequentially sweeping an ultrasound beam over a predetermined angle.

28. A method as recited in claim 1 for non-invasive vascular elastography (NIVE).

29. A method as recited in claim 25 for non-invasive microvascular elastography (MicroNIVE).

30. The use of the method from claim 1 for predicting risks of vascular tissue rupture or vascular aneurysms.

31. The use of the method from claim 1 for phenotyping in animal models using genetic or cloning technologies.

32. The use as recited in claim 31 wherein said model is hypertension (HT).

33. The use of the method from claim 1 for in vivo measurements.

34. A system for vascular elastography comprising:

an ultrasound system for acquiring pre-tissue motion and post-tissue motion radio-frequency (RF) images of a vessel; said pre-tissue motion and post-tissue motion images being representative of first and second time-delayed configuration of said vessel;

a controller, coupled to said ultrasound system, i) for receiving said pre-tissue motion and post-tissue motion RF images, ii) for digitizing said pre-tissue motion and post-tissue motion RF images, iii) for partitioning both said pre-tissue motion and post-tissue motion RF images into corresponding data windows, iv) for approximating a trajectory for each said data windows; and v) for using said trajectory for each said data window to compute a strain tensor in each data window; and

an output device coupled to said controller to output information related to said strain tensor in each data window.

35. A system as recited in claim 34, wherein said controller further includes an analog-to-digital acquisition board for digitizing said pre-tissue motion and post-tissue motion images.

36. A system as recited in claim 34, wherein said ultrasound system includes an ultrasound instrument, coupled to said analog-to-digital acquisition board.

37. A system as recited in claim 36, wherein said ultrasound instrument includes a scanhead.

38. A system as recited in claim 37, wherein said scanhead includes an array ultrasound transducer.

39. A system as recited in claim 37, wherein said scanhead includes a single-element oscillating transducer.

40. A system as recited in claim 36, wherein said ultrasound instrument includes a catheter having a tip and a transducer provided at said tip.

41. A system as recited in claim 36, wherein said ultrasound instrument is in the form of an ultrasound biomicroscope for non-invasive microvascular elastography (MicroNIVE) measurement.

42. A system as recited in claim 36, wherein said ultrasound instrument is coupled to said analog-to-digital acquisition board via a radio-frequency (RF) pre-amplifier.

43. The use of the system recited in claim 34 for predicting risks of vascular tissue rupture or vascular aneurysms.

44. The use of the system from claim 32 for phenotyping in animal models using genetic or cloning technologies.

45. The use of the system from claim 44 wherein said model is hypertension (HT).

46. A system for vascular elastography comprising:

means for providing pre-tissue motion and post-tissue motion images in digital form of a vessel; said pre-tissue motion and post-tissue motion images being representative of first and second time-delayed configuration of said vascular vessel;

means for partitioning both said pre-tissue motion and post-tissue motion images into corresponding data windows;

means for approximating a trajectory for each said data windows; and

means for computing a strain tensor in each data window using said trajectory for each said data window.